Optimizing Tensile Strength Using Infill Patterns and Nozzle Diameters

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3D printing, or additive manufacturing, has revolutionized various industries but faces challenges related to structural instability and material waste. Globally, 3D-printed models generate over 379,000 kg of plastic waste, with more than 30% of prints discarded. This study aims to identify the optimal combination of infill pattern and nozzle diameter to maximize tensile strength. Standardized ASTM D638 Type 1 tensile-testing models were designed using computer-aided design (CAD) software, printed with a commercial 3D printer, and tested using a universal tensile tester. We hypothesized that using a 0.6 mm nozzle diameter would increase tensile strength by improving material flow and interlayer adhesion, reducing internal defects and leading to a higher effective Young's Modulus. Additionally, we hypothesized that a triangular infill pattern would increase tensile strength by maximizing internal support through interconnected, angular patterns that evenly distribute stress. Results supported both hypotheses: samples with a triangular infill pattern exhibited higher tensile strength compared to rectilinear and honeycomb patterns, and prints with a 0.6 mm nozzle had a higher average tensile strength than those printed with 0.4 mm and 0.8 mm nozzles. These findings highlight the critical role of structural design in enhancing mechanical properties, contributing to the development of more efficient and durable 3D-printed products.

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